WHITE WATER ASSOCIATES REPORT

Gile Flowage Watershed Project Report: Environmental Information Review and Water Quality Monitoring (Iron County, Wisconsin)

Submitted to:

Towns of Carey and Pence
Iron County, Wisconsin
Joint Planning Committees
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Gile Flowage September 2005 (D. Premo photo)

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INTRODUCTION

In this document, we report the findings of an environmental information review and baseline water quality monitoring of the Gile Flowage in northern Wisconsin. This work was conducted under contract with the Town of Carey, Wisconsin with funding through the Wisconsin Department of Natural Resources (WDNR) Lake Planning Grants Program. Partners in this project include the Towns of Carey and Pence, a grassroots organization known as Friends of the Gile Flowage, the WDNR, and White Water Associates, Inc.[1]

Aquatic ecosystems and their surrounding landscape ecosystems are enormously complex. Our understanding of how they work is not complete. Our ability to predict outcomes from specific actions is uncertain. This means that ongoing monitoring is critical to any future management plan and actions. This report comes at a time when the affected human communities are undergoing the process of comprehensive land-use planning. This is fortunate timing as it means the Gile Flowage ecosystem can be considered as part of the greater watershed plan.

The health of a watershed and the health of local economies like those that exist in the Gile Flowage area are highly integrated. A sustainable economy depends on a healthy environment and this link is true at several scales. For example, property owners on Gile Flowage have invested in an ecosystem. The reasons that they own the property are typically linked to environmental quality. The economic value of their investment is linked to the health of Flowage and surroundings. If the ecological health declines, so does the value of the property in dollars.

At a slightly larger scale, this same principal linking the environment and economy applies to municipalities. Carey and Pence communities are caretakers of many ecosystems including the Gile Flowage. The long-term economic health of these municipalities is tied to the health of Gile Flowage and the associated streams in the area., as well as the land. At even larger scales yet, this applies to Iron County, to the State of Wisconsin, and so on.

Beside this section (Introduction), this report is organized in five principal sections: Study Area, History and Operation of Gile Flowage, Methods, Results and Discussion, and Recommendations for Comprehensive Land Use Planning. Appendix A contains figures (maps).

1 *White Water Associates, Inc., an independent ecological consulting firm and analytical laboratory from the western Upper Peninsula of Michigan, conducted this study and prepared this report. White Water has significant experience and expertise in aquatic and riparian ecology and chemistry in the Great Lakes states.*

STUDY AREA

The Gile Flowage is a 3,400-acre impoundment and located in Iron County, Wisconsin. About two-thirds of the Flowage lies within the jurisdictional boundaries of the Town of Pence and one-third in the Town of Carey. The Gile Flowage is classified as a Class 1 lake in Iron County's 2-tiered Lake Classification System. This is the least restrictive category using the minimum state shoreline setbacks and lot size restrictions.

Gile Flowage was created in 1945 when the West Branch of the Montreal River was dammed to form a water reserve for power generation at the downstream Superior Falls hydroelectric dam. The Flowage has two well-developed public access points with public piers and three "rustic" access sites. Gile Park has a swimming beach, picnic area, park, and pavilion. Tent camping is allowed on public lands around the Flowage and on islands.

The Gile Flowage is part of a larger watershed ecosystem that influences the Flowage. The land matrix of this watershed ecosystem is largely forested. Xcel Energy owns approximately 1,200 acres on the Gile Flowage. This ownership, combined with that of the county and towns, accounts for about ninety percent of the shoreline. Xcel's current policy is to leave the shoreline in natural condition. Xcel's shoreline is open to the public for non-consumptive uses. Foot traffic is allowed, but not all-terrain or other off-road-vehicles. Because Xcel has not enforced its property rights, there have been shoreline encroachments. These are being addressed with attempts to return the shoreline to a natural condition. The Wisconsin Natural Resources Code prohibits Xcel from allowing non-riparian owners to place structures (e.g., piers) on Xcel land.

The overall Montreal River watershed consists of the East Fork and West Fork of the Montreal River and many tributaries. The West Fork originates in Island Lake and flows through the Gile Flowage. Upstream of the Flowage, the West Fork is considered a warm water fishery with walleye, yellow perch, black crappies, northern pike, and occasionally brook trout (WDNR Description of Montreal River Watershed. Downstream from the Gile Flowage, walleye, muskellunge and some brook trout occur. Beaver and migratory waterfowl use the upper watershed. The West Fork of the Montreal River receives effluent discharge from the City of Montreal wastewater treatment plant. The mouth of the Montreal River in Lake Superior has been identified by the Lake Superior Binational Program as important to the integrity of the Lake Superior ecosystem for old growth forest, coastal wetlands, and fish and wildlife spawning and nursery grounds.

HISTORY AND OPERATION OF GILE FLOWAGE

The Wisconsin Public Service Commission approved the construction of a dam and reservoir on the West Fork of the Montreal River in order to augment flow to the downstream hydro facilities. Construction of the Gile Flowage dam was completed in December of 1940. It was built on the site of the Montreal River Lumber Company logging dam that dated back to the late 1800s. Lake Superior District Power Company was the first owner. This company merged in Northern States Power (NSP). In turn, NSP merged into Xcel Energy, the company that currently owns and operates the dam and much of the land that surrounds the Flowage.

The Gile Flowage dam is thirty feet high and 1,100 feet long. Discharge is controlled through a sluice and tainter. The smaller sluice gate (six feet wide and five feet high) is most commonly used for controlling discharge from the Flowage. The tainter gate (sixteen feet wide and twelve feet high) is used for water control during periods of high discharge (typically in the spring runoff period).

There is no power generated at the Gile Flowage dam. The purpose of the dam is to store water for release to two downstream hydroelectric facilities to maximize the efficiency and profitability of those operations. The two downstream dams are the Saxon Falls Dam (built in 1912) and the Superior Falls Dam (built in 1917). The combined generation of these two hydroelectric facilities is 22,000 megawatt hours per year (enough power for 2,600 homes).

The normal level for a full pond is at an elevation of 1,490 feet. The Wisconsin Public Service Commission issued orders for maintaining pond levels in 1936. The minimum flow out of the dam is 10 cubic feet per second (cfs). The maximum drawdown allowable is 15 feet (down to an elevation of 1,475 feet elevation). According to Rob Olson of Xcel Energy, since 1984 NSP and Xcel have decreased the drawdown to an average of 7 feet per season. He further reported that the summer drawdown averages six feet and the winter drawdown averages 7.5 to 8 feet. The summer drawdown generally begins around May 1 or when the runoff from snowmelt and spring rains end. The summer drawdown proceeds gradually until fall rains. The winter drawdown is used to provide water from downstream hydropower generation during the low-flow months. Xcel Energy is adamant that, without the ability to conduct seasonal drawdowns, the downstream hydroelectric facilities would not be economically feasible to operate and there would be no reason to own, operate, and maintain the Gile Flowage dam.

METHODS

The work effort resulting in this report has taken place during 2004 and 2005, including fieldwork in the ice-free season of both years. Three goals guided the effort during the 2004 phase of the work: (1) establish a framework for watershed planning using a comprehensive land use planning model, (2) identify issues and opportunities based on an assessment of existing research, and (3) identify new research needed to complete a comprehensive watershed plan. In support of these goals, White Water focused on four tasks: (1) review land use planning information, goals, and objectives developed by the Towns of Carey and Pence as part of their comprehensive land use planning process, (2) research, collect, and compile existing environmental information on the Gile Flowage, (3) identify threats to the Gile Flowage ecosystem and opportunities for management, and (4) identify gaps in the existing environmental information and recommend future environmental monitoring and research needed to support Gile Flowage watershed planning. The first year of work culminated in an oral report presented to the public in late fall of 2004 that summarized existing information, information gaps, key ecosystem features, threats to the Flowage, and priority actions recommended for the future.

We obtained existing information on the Gile Flowage on topics such as water quality, aquatic and riparian vegetation, fish and wildlife, rare organisms and habitat, non-native organisms, biologically sensitive or unique areas, and pollution sources by contacting resource agencies, utility managers, and lake volunteers. During 2004, we conducted a one-day reconnaissance field trip on Gile Flowage for purpose of becoming familiar with overall watershed and Flowage character as well as a general evaluation of obvious features and threats to the ecosystem.

During the 2005 phase, White Water continued with information gathering and review and began the process of lake water quality monitoring. These actions were intended to address information gaps identified during the 2004 work. An important component of the lake monitoring task was educating volunteers how to conduct water quality monitoring.

During summer and fall of 2005, we conducted two bouts of field-monitoring and lake volunteer education on Gile Flowage. During the summer bout we selected two locations for water quality sampling and three locations for sediment sampling (see Figure 1, Appendix A). During the fall sampling bout we collected water samples from one of the two water stations.

Two White Water staff conducted fieldwork during the 2004 season: Mr. David Tiller and Dr. Elizabeth Rogers. They used White Water's 14-foot, V-hull aluminum boat, outfitted with a

10HP Honda four-stroke, long-shaft engine. Dr. Dean Premo (White Water Associates) conducted the fieldwork in 2005 assisted by Friends of the Gile Flowage volunteers and using a pontoon boat and motor supplied and navigated by Catherine Techtman and her husband Harold.

During the August 7, 2005 sampling bout we selected a fairly deep point in the reservoir (WP 299 shown on Figure 1) where we anchored the boat with a long line in order to conduct water quality observations and obtain water for testing at the laboratory. We measured water transparency using a Secchi disk. We measured specific conductance and pH of the water using a handheld Myron L Ultrameter™ 6P. We also measured dissolved oxygen and temperature (in the form of a depth profile) using a handheld YSI Model 51B meter. Each of the instruments used during the study was done so in accordance with the manufacturers' suggested methods.

Since we observed no temperature and dissolved oxygen stratification, we collected a water sample from the epilimnion (surface) only. These samples were tested for alkalinity, nitrate-nitrite nitrogen, total Kjeldahl nitrogen, total phosphorus, total suspended solids, and total organic carbon. A chlorophyll "a" sample was collected as an integrated sample of the photic zone (two times the Secchi disk transparency depth). At WP299, we also collected a sediment sample using a Ponar sampler. The sediment sample was brought back to the laboratory for determination of arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc. We later collected sediment samples from two additional locations WP300 and WP302.

We established a second water quality monitoring station at WP301 where we collected water samples for the laboratory. During the September 11, 2005 sampling bout, we collected a single set of water data from the WP301 station. During this bout, we also collected a low-level mercury sample using "clean techniques" (USEPA Method 1631).

Water samples (including the low-level mercury sample) were delivered to the Wisconsin State Laboratory of Hygiene via overnight delivery. White Water Associates laboratory conducted the analyses of sediment metals.

RESULTS AND DISCUSSION

In this section we present and discuss our findings and observations in thirteen subsections: (1) Land Use Planning, (2) Views from the People, (3) Aquatic Habitat, (4) Aquatic Vegetation, (5) Riparian Habitat and Aesthetics, (6) Flowage Fishes, (7) Area Wildlife, (8) Unwanted Invaders, (9) Potential Sources of Pollution, (10) Historical Water Quality, (11) 2005 Water Quality Monitoring: Field Measures, (12) 2005 Water Quality Monitoring: Water Chemistry, and (13) 2005 Water Quality Monitoring: Sediment Chemistry.

Land Use Planning

Environmentally grounded comprehensive land-use plans will be great assets to the Towns of Carey and Pence. In addition to guiding decisions, they can be proudly presented to prospective new residents and businesses as an indication of how seriously the community and local governments regard the maintenance of a healthy environment and a northwoods aesthetic. In general, the viewpoints expressed by respondents to the Comprehensive Plan Surveys for the Towns of Carey and Pence reflect opportunities for exciting environmental stewardship that integrates a large natural area and the towns. For example, respondents were amenable to healthy setbacks and lot width restrictions for any development on the Gile Flowage. Respondents ranked "tourism" of second highest importance for Iron County to attract and solicit to its economy. "Light industry and manufacturing" was rated first and "forestry" was rated third. Importantly for cooperative watershed stewardship, 90% (Town of Carey survey respondents) and 93% (Town of Pence survey respondents) felt that neighboring municipalities should work together toward shared goals. About 50% of the respondents to the Comprehensive Plan Surveys for the Towns of Carey and Pence expressed that more restrictive standards are necessary for shoreland and water quality protection of the Gile Flowage and other areas of Iron County, Wisconsin. About one-third of the respondents noted that Iron County zoning regulations need to be improved to protect water quality in the county.

The draft goals and objectives for the Town of Pence Land Use Comprehensive Plan contain some real opportunities for environmental stewardship. Some of these goals and objectives are good "as is" whereas others would benefit by greater elaboration. For example, under the "Transportation" section that speaks to "preserving aesthetic qualities of the Town," an objective could be added that addresses stream crossings and drainage culverts so that environmental impacts such as erosion or drainage alterations are minimized or mitigated. A similar objective could be added that speaks to wetland protection during road projects that goes beyond the bare minimum of silt fence installations.

Under the "Utilities, Community Infrastructure, and Public Health" goals, an objective calls to limit utility corridors to existing ROWs. This is very beneficial from an ecological standpoint. More could be made of this objective in order to strengthen the point. For example, it could be stated one reason for this objective is to reduce habitat fragmentation and minimize future use of herbicides in ROW clearing.

Under the "Intergovernmental Cooperation Section," the objective to work with adjoining towns and county in developing future land use and zoning to avoid "patchwork" land use and zoning patterns and promote consistent regulations across jurisdictional boundaries is good and would benefit by greater specificity or perhaps some examples. The objective that specifies participation with neighboring towns and the county to formalize intergovernmental relationships and the objective that asks for cooperation with the Town of Pence to develop watershed scale land use plan for the Gile Flowage are both excellent and might be strengthened by a statement that indicates how such a plan for the Gile Flowage will be an integral part of the Comprehensive Plan. Several of the objectives under the "Housing" goal will be beneficial toward limiting the footprints of human development in the watershed and minimizing habitat fragmentation. These benefits and others could be more explicitly stated.

Under the "Natural Resource, Cultural Resource, and Recreation" goal, the objective that calls for encouraging the Town and County not to sell property on the Gile Flowage so that it can remain in public ownership and use is also critical to minimizing habitat fragmentation and water quality impacts of development. These values should be articulated in this objective. The objective to "preserve streams, drainages, flood plains, wetlands, wildlife habitat and the continuity of larger woodland areas, and other natural features that enhance environmental quality, wildlife, and the Town's northwoods character" is excellent and deserves further elaboration of the potential benefits of this objective. The objective that calls for "encouraging the County to enforce shoreland zoning regulations along rivers, streams, and lakes to protect water quality and aesthetic character of these areas" is also excellent, but what will be the method of "encouragement"? Are the penalties for ignoring zoning regulations sufficient to discourage abuse? The objective that states, "seek improvement of Gile Flowage boat landings..." is also good. This objective could also include some language regarding the washing of boats and trailers that enter and leave the lake to minimize opportunity for non-native species immigrations/emigrations. Educational kiosks that address non-native species impacts might also be incorporated into this objective regarding boat landing improvements.

Under the "Natural Resource, Cultural Resource, and Recreation goal, the objective that calls for "cooperating with County Forestry Department in development of the 15 year County forest plan" is excellent, but should perhaps be more explicit that the Town of Pence will articulate to the Forestry Department its own goals and objectives to ensure that the forest plan reflects these goals wherever possible. The final two objectives concerning Gile Flowage islands and working with Friends of Gile Flowage to address issues of recreational use on the Flowage are excellent, although the latter objective should be expanded to include more than just recreation.

The "Economic Development" goal has three objectives with opportunity for watershed stewardship. The objective that states, "require all mineral extraction activities to have a reclamation plan" is a very important objective. It should be expanded to include that a monitoring component is required to ensure that reclamation has been implemented successfully. The objective to "limit commercial development to the Highway 77 corridor" is good as it minimizes the ecological footprint and reduces habitat fragmentation in addition to aesthetic benefits. Finally, the objective to "encourage value-added forest product industry and home-based business development" are good. Local prosperity means more concern for environmental quality and more financial commitment to affect desired outcomes.

Under the "Land Use" goal, the first five objectives (land use plan, direct new development, preserve natural aesthetic character, subdivision regulation, and discourage fragmentation) are all good objectives that will serve to minimize the impacts of future development on the watershed. The objective that calls for working with the Town of Carey and Friends of the Gile Flowage on development of an integrated Gile Flowage watershed plan is also excellent. The broader comprehensive land use plans drafted by the Towns should also reference the Gile Flowage plan. In the final objective under this topic (encouraging tree plantings and natural vegetative screening), reference should be made to the use of native plant species for these plantings.

At the time of this review the Town of Carey had not developed its goals and objectives quite as much as the Town of Pence. Nevertheless, there was excellent opportunity for environmental management and these deserve mention here. Under the "Land Use" goal (maintaining the rural character of the community), the minimum lot size and water frontage width objectives show promise for environmental health. Under the "Agriculture, Natural, and

Cultural Resources" goal (to ensure that agricultural and natural resources are protected), several objectives hold promise toward minimizing human impact. These included developing the Gile Flowage plan, limiting shoreland development to single family homes, prohibit shoreline key-holing, and clearly define and use zoning control to regulate water quality.

Views from the People

The University of Wisconsin Cooperative Extension Service conducted a survey of people from the Gile Flowage watershed in 2004. The purpose of the survey was to determine the perspectives of the people potentially most connected to the Gile Flowage. A total of 252 surveys were returned from the communities of Carey, Pence, and Montreal averaging a high response rate of about twenty-seven percent. Questions were asked under the categories of (1) satisfaction, value, and use, (2) land use and development, (3) recreational use, (4) water quality, (5) exotic species, (6) public access, and (7) vision for the future. A few of the responses are discussed in this section.

The most valued characteristic of the Flowage is *scenic beauty* with about 27% of respondents indicating this choice. *Fishing* was second at about 20% of responses. *Scenery* also scored highest relative to "on-land" uses of the watershed (33%) with *walking* taking a close second (25%). The most popular on water use was *fishing* garnering over 50% of the responses when ice fishing was included. *Swimming and boating* (canoe and motororized craft) were also important.

Ninety-six percent of respondents felt that land use and development issues were "somewhat" or "very" important in the watershed. Ninety-seven percent felt that it was important to preserve the "Northwood's character" of the area (84% felt it was very important). Most (62%) respondents felt that the amount of development in the watershed is about right with 16% reflecting the amount of development was already excessive.

About 60% of respondents answered that *on-the-water recreation* is very important and 31% responded "somewhat important." More than half of the respondents (56%) feel that recreational use of the Flowage has increased over the past several years, but most felt that this increase has not diminished their enjoyment of the Flowage. Eighty-five percent of the respondents were in favor of enhanced fishing through stocking or construction of cribs.

A large number of respondents (98%) reflected that *water quality* of the Gile Flowage is important (83% responded "very important"). Most respondents (76%) believe that water quality has remained about the same over the past several years and that current water quality does not diminish their enjoyment of the Flowage.

When it comes to *exotic species* of plants and animals, over 90% of the respondents reflected that it is an important issue, even though only a few respondents (13%) indicated that they have actually noticed exotic species. A slight majority responded that their enjoyment of the Flowage is negatively affected by exotic species. Most respondents (84%) were in support of improving education and awareness regarding exotic species.

Regarding the public's *vision for the future*, over half (52%) agree that there should be a high priority placed on protecting nature. Most respondents (88%) expressed support for *long range planning* for the Gile Flowage watershed.

Aquatic Habitat

The Gile Flowage is a 3,400-acre reservoir. The shoreline consists of approximately twenty-six miles of irregular shaped "points" and "bays" with numerous areas of exposed bedrock and out-cropping. Several large islands are located in the center of the Flowage and there are numerous smaller islands scattered throughout the impoundment. During periods of low water, nearly exposed rock islands can be hazardous to navigation (WDNR 1996 Lake Survey Summary).

The Gile Flowage receives water from seven inlet streams (WDNR 1996 Lake Survey Summary) with the West Fork of the Montreal River being the largest contributor. The other streams include: Linnunpuro Creek, Luoma Creek, Black Creek, Birch Creek, Meads Creek, and an unnamed creek that enters the Flowage in the SW1/4 of the SW1/4 of Section 15. A 25 foot dam at the north end of the Flowage controls the water level according the needs of downstream hydroelectric facilities. Water levels vary dramatically throughout the year with fluctuations of up to 15.5 feet recorded. According the 1996 WDNR Lake Survey, a typical year water level regime includes near full pool (elevation 1,490 feet) during May with gradual drawdown through October (up to about 8 feet). Refilling occurs in late fall for use during the winter. Maximum drawdown is generally reached in late February or early March. The WDNR (1996) reported that the average drawdown of 8 feet and a range of 5.7 to 11.1 feet over a twelve year period.

An undated map included as Appendix I in the WDNR 1996 Lake Survey Summary depicts the various substrate types and other habitat features in Gile Flowage. Substrate features include muck, sand gravel, rubble, boulders, and bedrock. Habitat features mapped include marsh, floating vegetation, submergent vegetation, emergent vegetation, brush shelters, submerged rock, and stumps and snags. This map is reproduced as Figure 2 (Appendix A).

One of the apparent effects of significant periodic water level fluctuations is the reduction of large woody material (logs, wind-thrown trees) in the littoral zone (shallow water areas around the lake). Woody material, if submerged, can remain in lakes for decades and centuries without loss of structural habitat value. In the Gile Flowage, however, this structure is frequently exposed to air hastening the deterioration. Fluctuating levels tend to dislodge this material from the shoreline and remove it from some of the best habitat areas on the Flowage. This material then tends to float around the Flowage or piles up along shorelines rather than extending out into the littoral zone where it would provide better cover for fish and other aquatic organisms.

Aquatic Vegetation

The extreme fluctuations of water levels in the Gile Flowage likely make it difficult for some aquatic plant species to establish. They are exposed to harsh conditions under the drawdown periods. The 1996 WDNR report cited in the previous section contained a map of floating and submergent vegetation in the Gile Flowage (see Figure 2, Appendix A).

The Gile Flowage was included as part of a study of aquatic plant communities in eight northern Wisconsin flowages.[2] Authors of that study concluded that large bedrock outcrops and large fluctuation in water level cause the plant community to be sparse in many areas of the Gile Flowage. The maximum depth of plant growth found during the study was 0.40 meters. Twenty-three aquatic plant species were found in the Gile Flowage (see Table 1) although the diversity index was relatively low because individual species frequencies were low on the transects.

2 *Weber, Steven P., Byron Shaw and Stanley A. Nichols 1996. The aquatic macrophyte communities of eight northern Wisconsin flowages: St. Croix, Gile, Minong, Brule, Rainbow, Willow, Caldron Falls, and Big Eau Pleine.*

Table 1. Aquatic plants found in Gile Flowage in August 1994

(Weber, Steven P., Byron Shaw and Stanley A. Nichols 1996. The aquatic macrophyte communities of eight northern Wisconsin flowages: St. Croix, Gile, Minong, Brule, Rainbow, Willow, Caldron Falls, and Big Eau Pleine.)

Plant Species	Common Name	Type	Relative Frequency on Transects
No Vegetation	--	--	78.1
Elodea nutallii		Submergent	6.1
Potamogeton fresii	Frie's Pondweed	Submergent	3.2
Nitella Sp.	Stonewort	Submergent	2.9
Sparganium chlorocarpum	Geen-fruited Burr Reed	Emergent	2.5
Callitriche verna	Water Stonewort	Submergent	2.2
Eleocharis acicularis	Spikemoss	Submergent	1.5
Potamogeton alpinus		Submergent	0.8
Potamogeton gramineus	Variable Pondweed	Submergent	0.5
Alisma plantago-aquatica	Water Plantain	Emergent	0.5
Juncus filiformus		Emergent	0.5
Sparganium eurycarpum	Giant Burr Reed	Emergent	0.5
Najas flexilis	Bushy Pondweed	Submergent	0.3
Potamogeton epihydrus	Natall's Pondweed	Submergent	0.2
Sagittaria sp.	Arrowhead	Emergent	0.1
Potamogeton nodusus	River Pondweed	Submergent	0.1
Sagittaria latifolia	Arrowhead	Emergent	0.1
Scirpus cypernus	Woolgrass	Emergent	*
Typha angustifolia	Narrow leaf cattail	Emergent	*
Eleocharis intermedia		Emergent	*
*Callitriche hermaphrodictica***	Water Stonewort	Submergent	*
Phalaris arundinacea	Reed Canary Grass	Emergent	*
Potamogeton natans	Floating Leaf Pondweed	Submergent	*
Polygonium amphibium	Water Smartweed	Emergent	*

* *These plants not found on transects, but somewhere in the Flowage*
** *Considered rare in Wisconsin*

Elodea nutallii and *Potamogeton fresii* were found with the greatest frequency on transects. *Callitriche hermaphroditica* (considered rare in Wisconsin) was found in some places on the Flowage. Only 15% of the 26-mile shoreline littoral zone was vegetated (85% was devoid of aquatic plants). Seventy-four percent of the vegetation taxa was composed of submergent forms and 24% of these were species sensitive to water quality degradation.

According to the Weber, Shaw, and Nichols (1996) study, submergent plant populations can be good early indicators of water quality degradation. Fewer species of submergent plants means lower water quality. Disturbance from water level fluctuation and light limitation from algae, suspended solids, and water color can influence the presence of many species. Of the eight flowages studied by Weber, Shaw, and Nichols (1996), the Gile Flowage was among the lowest in percentage of submergent plant species. Gile Flowage ranked seventh (out of eight flowages) with aquatic plants favored by wildlife and it ranked last relative to frequency of fisheries-valuable species of aquatic plants.

During a field reconnaissance trip to the Gile Flowage in 2004, White Water Associates' staff observed several species of emergent vegetation, including *Juncus filiformis, Potamogeton obtusifolius, Sparganium minimum* (native), *Braseria schreberi*, and *Salix discolor*. On that same field trip we observed some evidence of blue-green algal bloom on the Flowage indicating that nutrient conditions must be at times suitable for these to occur. Although not observed on the Gile Flowage, blue-green algae blooms can create significant odors and release biotoxins that are of human-health concern.

Riparian Habitat and Aesthetics

The riparian area of the Gile Flowage is comprised of a very diverse and healthy appearing forests and wetlands. The larger proportion appears to be upland forest. This upland habitat is juxtaposed with wetland opening and lowland forest, giving a very "northern" and pristine look to the Flowage. This area is undoubtedly habitat for many songbirds and waterfowl. We observed bald eagles, mallards, wood ducks, hooded mergansers, and several species of warblers.

Because much of the land surrounding the Gile Flowage has been controlled by the power company, buildings and other development is at a minimum. In an age of increasing development pressures in northern Wisconsin, views of uninterrupted shorelines are rare, but the Gile Flowage is a wonderful exception. This paucity of development combined with the islands and mature forests riparian forests of the Flowage provides a very wild and pristine atmosphere.

Flowage Fishes

Game fishes in the Gile Flowage include walleye, smallmouth bass, muskellunge, northern pike, yellow perch, rock bass, black crappie, and pumpkinseed. In addition, black bullhead and golden shiner were recorded in 1993 fish surveys. In there 1996 Lake Survey Summary/Fisheries Management Plan, the WDNR listed walleye, smallmouth bass, and muskellunge as "major" fish species and northern pike and black crappie as "minor" fish species (relative to recreation).

The 1996 WDNR Lake Survey Summary/Fisheries Management Plan for Gile Flowage indicated that over the 1950s, 1960s, and 1970s there were a few basic fish surveys conducted in the Flowage. A 1973 survey recommended continuing walleye and musky management and resume annual musky stocking. Some netting surveys continued in 1984 and 1988 for trend information. In 1984, fall walleye fingerling index stations were established and used to monitor annual production since that time.

Past stocking in Gile Flowage consisted of various species on an annual basis during the 1940s including bluegill, largemouth bass, musky, suckers, and minnows. Walleye fingelings were introduced in 1952 and 1953. All stocking was ceased between 1955 and 1965. Musky plantings resumed in 1966 and continue annually through the time of the 1996 WDNR report. In 1985, smallmouth bass were introduced and stocked for three consecutive years.

According the 1996 WDNR report, 64 log crib shelters were installed between 1989 and 1993. Musky have been managed with a 40-inch size limit and smallmouth bass with a 15-inch and 2 fish bag since their introduction.

The most recent fish population data provided by the WDNR was the 1996 Lake Survey Summary/Fisheries Management Plan. This plan evaluated fish population surveys conducted in 1993 and annual monitoring of natural walleye year class production and survivorship to yearling stage and the findings are summarized here.

For walleye, the size structure and distribution of the population were found to be relatively good although population densities were thought to be well below carrying capacity of the Flowage. The eastern bay of the Flowage (Sections 1, 2, and 11) is identified as the major spawning area with other areas throughout the Flowage providing abundant spawning habitat as well. The WDNR did not consider natural walleye reproduction as a limiting factor, in fact during some years reproduction is outstanding because of the abundant spawning habitat. Twelve years of fall fingerling production data from the Flowage demonstrated similar trends as other naturally reproducing walleye populations, but even during years of outstanding walleye production, negligible increases in yearling abundance were observed suggesting that the young fish were having a difficult time overwintering. This lead the WDNR to surmise that the dramatic winter drawdowns in the Gile Flowage may be the important factor in this lower winter carrying capacity. The overall result is that fewer walleyes survive into adulthood. The WDNR 1996 report cites that survival of young-of-the-year walleye to yearling stage averaged just over 14% during the twelve-year study, whereas other self-sustaining walleye populations demonstrate survival rates exceeding 20%. The WDNR Fisheries biologists surmise that duration of maximum drawdown in late winter may be critical to survival of young walleyes. The WDNR report did not speculate on the effect that winter drawdown might have on other fish species.

The 1996 WDNR survey reported that smallmouth bass had developed into a good fishery in the Gile Flowage (WDNR1996). Natural reproduction was supporting the fishery. Musky growth rate was good at all age classes, but although natural reproduction was evident the WDNR concluded that supplemental stocking (alternate year basis) was necessary. Northern pike in the Flowage was similar to other area lakes with size distributions rather truncated at about 20 inches, poor average growth, with total mortality, and few fish that attain large size. Gile Flowage panfish populations showed low abundance and good growth. Black crappie and rock bass predominate.

Area Wildlife

Bruce Bacon (WDNR Wildlife Biologist) conducts a survey for loons once every five years and consistently records two to three pairs of common loons on Gile Flowage (Bacon pers. com.). In addition there were two active bald eagle nests on the Flowage, but one has recently fallen down. There was one active nest in 2004 (Bacon, pers. com.). Ospreys have attempted nesting on the Flowage, but have never been successful.

The expansive and largely uninterrupted forested riparian area makes ideas habitat for migrant and resident birds. This includes many Neotropical migrant bird species. In fact, this kind of riparian habitat often form important resting places for birds during migration offering food in the form of midges and other insects emerging from the Flowage and protective cover in the riparian forest.

Almost certainly, gray wolves use the watershed of the Gile Flowage as part of much larger home ranges. The Flowage itself also has potential as stopover habitat for rarely observed birds such as trumpeter swans and a large expanse of water for migrating waterfowl during both spring and fall migrations.

The West Fork of the Montreal River was identified in the WDNR Coastal Wetlands Evaluation (Epstein 1997) as an aquatic priority site. While only seventeen invertebrate taxa were collected in the initial collection effort, two of these were very rare species in Wisconsin. The predominant groups were mayflies and caddisflies. The Coastal Wetlands Evaluation cited turbidity (in the stream) and the impoundment itself as presenting challenges to the maintenance of water quality.

Unwanted Invaders

Non-native invasive species of plants and animals are a major concern in inland lakes in Wisconsin. Two such species are known to be in the Gile Flowage: the Chinese Mystery Snail and the Spiny Waterflea. Each species is capable of large population booms with potential negative consequences for other organisms within the ecosystem.

The Chinese Mystery Snail (*Cipangopaludina chinensis* or, in some literature, *Viviparus malleatus*) is present in Gile Flowage and has been observed by residents and users of the Flowage. This is a large snail, one to two inches in length and olive brown. In conjunction with the Gile Flowage project, we spoke to Craig Roesler, a WDNR biologist (Hayward, Wisconsin) whose job it is to monitor exotic-invasive species. He verified that the Chinese Mystery Snail had been found in the Gile Flowage and some other northern lakes in Wisconsin, but that so far no ecological problems associated with the snail have been observed in the Wisconsin populations.

The Chinese Mystery Snail has been discovered in states from New York to Washington and down to the Gulf States. The probable mechanism for introduction of the snail into lakes is by way of aquarium owners who sometimes empty the contents of aquaria into lakes rather than dispose of them properly. Snails (including the Chinese Mystery Snail) can be purchased in pet stores and are used in cleaning aquaria glass.

Spiny Water Fleas (*Bythotrephes cederstroemi*) were discovered in the Gile Flowage in 2003 as part of a 64-lake survey conducted by the Limnology Center at Trout Lake (University of Wisconsin). This is the first and only known occurrence of the animal in a Wisconsin inland lake. It is not known how long spiny water fleas have been in the Gile Flowage. The non-native spiny water flea was accidentally introduced in the waters of the Great Lakes through ship ballast water from Europe. It apparently arrived in the Great Lakes during the 1980s.

Spiny water fleas are predatory crustaceans. They eat smaller native planktonic crustacea such as *Daphnia* and *Ceriodaphnia*. The native planktonic crustacea are the food source of juvenile fish and adult sunfish and bluegills. Great numbers of the spiny water fleas could crop the forage base for these fishes and render the ecosystem less productive of fish species. Spiny water fleas are capable of rapid population increases and their long spiny tails make them difficult for small fishes to eat. In fact, their sharp spines can pierce the lining of a fish's gut and cause potential harm to individual fish.

Spiny water fleas can be transported on recreational equipment from one body of water to another. They have special "resting eggs" that can survive extreme conditions. The spiny water flea is not only a significant concern for the Gile Flowage but for lakes in the entire region as the Gile Flowage would be a likely source of introductions to other bodies of water. According to a Wisconsin Department of Natural Resources bulletin, no effective strategy is known for controlling spiny water fleas once they are established in a lake. The Limnology Center and the WDNR are attempting to educate recreational users of the Gile Flowage that spiny water fleas can be transported in live wells and bilge water and that the eggs can become attached to fishing tackle, anchor lines and mud on boats and anchors. Informational fliers advising lake users of the potential spread of spiny water fleas have been posted at each of Gile Flowage's boat landings and in local bait and boating stores.[3]

The WDNR is monitoring the population of spiny water fleas in the Gile Flowage. In a 2004 report, entitled "2004 Gile Flowage Data on Spiny Water Fleas and Other Related Information," WDNR biologist Craig Roesler reports on results of sampling at four sites on the Gile Flowage and considers two potential control options: (1) enhancement of planktivorous fish populations (bluegills and crappies) and (2) drawdowns to flush spiny water fleas from the Flowage. Roesler cites one case in a Minnesota flowage where planktivorous fish were believed to have been responsible for the disappearance of a population of spiny waterfleas (according to Roesler, fish larger than four inches can feed on the spiny water fleas). Roesler goes on to report that bluegill and crappie are present in the Gile Flowage in relatively low number due to the low amount of aquatic plants. The possibility of a drawdown treatment to flush away the spiny water fleas was found to be untenable because of the other impacts of drawdown on walleye and other

3 *Additional info can be found at http://limnology.wisc.edu/personnel/pieter/Hidden%20Stuff/Bytho.htm and http://www.wnrmag.com/supps/2005/jun05/edge.htm#2*

fish species and the great uncertainty as to the effectiveness of the treatment for removing spiny water fleas.

Potential Sources of Pollution

Several potential sources of non-point source (NPS) pollution for the Gile Flowage and its watershed exist. Primary among these is erosion and deposition of sediment. The dramatic fluctuations in the Flowage that result from summer and winter drawdowns expose areas to erosion from wind and wave action. Streams that enter the Gile Flowage also have potential to carry loads of sediment that emanate from bank erosion or poorly constructed stream crossings upstream of the Flowage. Some of this occurs in the headwater sections of streams. Sediments that are mobilized in the Flowage can deposit on spawning habitat and degrade the extent and quality of these areas.

NPS pollution could also emanate from runoff of sediment and nutrients from agricultural or forestry practices, although given the landscape these are of minimal consequence except in the instances of road building and stream crossing. In rare instances spills of fuel or other materials carried on nearby roads could drain into the Flowage. Runoff of oils and grease from roadways is also a possibility as is spillage of fuels from watercraft.

Airborne pollutants arising from distance sources can fall into the Gile Flowage through particulate matter, rain, and snowfall. This is a potential source for mercury in the Flowage.

Biological pollution, that is the introduction of non-native species, also has potential to impact the Gile Flowage. The spiny waterflea and Chinese mystery snail are examples of species that have already invaded the watershed. Other species with high potential for introduction are Eurasian milfoil and purple loosestrife.

Light pollution (primarily an aesthetic impact) will potentially occur with increased development and is of concern to Gile Flowage users. Gile Flowage is quite unique in that very little artificial lighting is visible from the lake after dark.

Historical Water Quality

A 1996 WDNR Lake Survey Summary/Fisheries Management Plan for Gile Flowage reported that the water is dark brown stained with a Sechhi Depth of 4.5 (presumably feet). The report indicated that the Flowage is "moderately fertile," (no nutrient measures were given) and with a "neutral pH". Maximum depth was reported as 25 feet. The report indicated that the Flowage does not thermally stratify and dissolved oxygen remains suitable for fish survival throughout the year even during low winter water levels. The 2004 WDNR report on spiny water flea monitoring (Craig Roesler, DNR, Hayward, December 2004) compiled and reported some historical WDNR water quality data. For completeness, that data is included in Table 2.

The Federal Energy Regulatory Commission (FERC) is responsible for licensing of hydroelectric facilities and other types of dams throughout the United States. FERC license articles often specify environmental monitoring that provides periodic and ongoing data. In spite of the fact that the Gile Flowage is maintained for the purposes of regulating water flow to two downstream hydroelectric facilities, FERC has not claimed jurisdiction over the Gile Flowage dam and impoundment and therefore no environmental monitoring data exists from that source.

The Gile Flowage is on the WDNR list of 303d Degraded Lakes (that is, it does not meet the standards of the U.S. Clean Water Act, Section 303d). Designation for listing is based solely on objective measures of water quality (in this case, mercury concentrations found in fish flesh. The 1996 WDNR Lake Survey Summary/Fisheries Management Plan for the Gile Flowage indicated that a health advisory for mercury-contaminated walleyes went into effect in 1986.

Table 2. Summary of WDNR water quality data for Gile Flowage (Roesler, 2004)

Date	Secchi depth (ft)	Temp-erature (C)	Tot. Phosph-orus (mg/L)	C'phyll "a" (ug/L)	pH	Alkalinity (mg CaCO3/L)	Calcium (mg/L)	Magnesium (mg/L)	Total Nitrogen
5/5/1994	5.2	18	0.018	4.2	7.3	16	5.6	2	0.57
6/21/1994	4.3	13	0.013	6.3	6.4	--	--	--	--
8/3/1994	4.3	32	0.032	6.9	7.6	--	--	--	--
8/29/1994	6.6	24	0.024	5.1	7.3	--	--	--	--
3/15/1995	--	19	0.019	2.1	7.0	--	--	--	--
5/2/1995	4.3	18	0.018	6.0	6.9	17	5.3	1.5	0.60
5/21/1997	5.3	38	0.038	--	7.2	--	--	--	--
8/14/1997	4.3	32	0.032	--	7.2	--	--	--	--
4/13/2000	7.5	19	0.019	--	--	--	--	--	--
6/13/2000	6.1	19	0.019	3.0	7.3	--	--	--	--
7/20/2000	6.0	23	0.023	5.0	7.0	--	--	--	--
8/9/2000	5.0	30	0.030	4.7	--	--	6.4	1.7	0.84

2005 Water Quality Monitoring: Field Measures

We conducted our water quality sampling work at WP299 and WP301 in the Gile Flowage (see Figure 1). The water depth at these two sites was about 6 meters and 3 meters respectively.

Based on visual inspection, the water in the Gile Flowage has rather low transparency. The Secchi disc depth was only 1.0 meter on August 7, 2005 and 1.5 meter on September 11, 2005. Water clarity results from two main influences: water color (materials actually dissolved in the water) and turbidity (materials suspended in the water such as silt or algae). In the case of the Gile Flowage, the water is quite tannin stained (tea-colored) and there is also suspended material in the water. Secchi disc values vary throughout the summer as algal populations fluctuate. In a river-influenced system, suspended particles can be imported to the system from upstream. Year to year changes can result from weather and nutrient changes.

Oxygen gas dissolves in water and is crucial to the survival of most aquatic organisms. The amount of oxygen that can dissolve in the water depends on the water temperature (colder water can hold more oxygen in solution). For example, in water that is well mixed with air at 32 degrees Fahrenheit the solubility of oxygen in water is 15 mg/L (or ppm – parts per million). At 50 degrees, the oxygen solubility is 11 ppm. At 77 degrees, the oxygen solubility is 8 ppm. Despite this, oxygen levels in water often differ from these figures as mixing is seldom complete and biochemical processes in the lake consume or release oxygen. Photosynthesizing plants produce oxygen during daylight hours, but these same plants use oxygen in their respiration (at night oxygen consumption by plants far exceeds production). Decomposition of dead organic material uses oxygen. At deeper spots in a lake (below where light can penetrate) oxygen can become depleted because of decomposition of organic material.

Lakes that are at least moderately deep often undergo summer stratification – the less dense warmer water stays near the surface and the denser colder water stays near the bottom. Thus the deep-water areas do not mix with the surface and therefore have no source of oxygen. Lower, colder levels of the lake become oxygen depleted. With stratified lakes, fall temperatures cool the surface water making it denser. Eventually, the surface water sinks to the bottom and mixes the lake. The Gile Flowage did not show stratification in the temperature and dissolved oxygen profile (see Table 3, below). Perhaps the large surface area of the Flowage and relatively shallow water allows for nearly complete mixing to result from wind and wave action. During the August sampling bout, in water deeper than 4.5 meters, however, oxygen levels were fairly low on the day of our sampling. The minimum amount of oxygen needed for "warm water" fish to survive and grow is 5 mg/L. The minimum standard for trout is 7 ppm.

Table 3. Temperature and Dissolved Oxygen Profiles for Gile Flowage.				
DEPTH	SUMMER SAMPLING (8/7/200505) at Gile Flowage WP299		FALL SAMPLING (9/11/2005) at Gile Flowage WP301	
	TEMPERATURE	DISSOLVED OXYGEN	TEMPERATURE	DISSOLVED OXYGEN
Surface	23.0°C	5.90 mg/L	26.8°C	6.80 mg/L
0.5m	23.0°C	5.85 mg/L	25.2°C	7.00 mg/L
1.0m	23.0°C	5.90 mg/L	23.4°C	7.00 mg/L
1.5m	23.0°C	5.95 mg/L	23.0°C	7.00 mg/L
2.0m	23.0°C	5.95 mg/L	23.6°C	7.00 mg/L
2.5m	23.0°C	5.95 mg/L	22.6°C	6.50 mg/L
3.0m	23.0°C	6.00 mg/L	22.2°C	5.80 mg/L
3.5m	23.0°C	5.90 mg/L	--	--
4.0m	23.0°C	6.00 mg/L	--	--
4.5m	23.0°C	6.00 mg/L	--	--
5.0m	23.0°C	4.50 mg/L	--	--
5.5m	23.0°C	4.50 mg/L	--	--
6.0m	23.0°C	4.50 mg/L	--	--
6.5m	23.0°C	1.00 mg/L	--	--

Field measured pH values for the Gile Flowage were 7.35 s.u. (August 7) and 8.06 s.u. (September 11). Conductivity was measured at 55.21 microseimens/cm (August 7) and 39.9 microseimens/cm (September 11) indicating a rather low amount of dissolved material in the water.

2005 Water Quality Monitoring: Water Chemistry

Table 4 presents the analytical chemistry data from water samples collected on August 7 and September 11, 2005 from the Gile Flowage. This subsection interprets and discusses the results.

Alkalinity acts as a buffer against acidification and the alkalinity levels measured in the Gile Flowage (14.3 mg/L on August 7, 2005 and 13.2 mg/L on September 11, 2005) indicate that the Flowage is fairly insensitive to acid precipitation. The Gile Flowage pH (a measure of acidity) was on the basic side of neutral (for context, neutral pH is 7 and an acidic lake would be pH=5). Minerals in the soil and watershed bedrock influence surface water alkalinity. If a lake gets groundwater from aquifers containing limestone minerals, alkalinity will be high.

The total phosphorus concentrations measured in the Gile Flowage were 0.034 mg/L (August 7) and 0.041 mg/L (September 11). These values are below average for impoundments (a good thing). The Gile Flowage Lake would be placed in a "good to fair" water quality index with regard to this nutrient. With respect to phosphorus concentration, the Flowage would be described as *eutrophic*.

The value for nitrate-nitrite nitrogen in August was below detection levels indicating that whatever nitrogen that was present was sequestered in algae and plants. Total Kjeldahl nitrogen during the August bout was 0.67 mg/L. On September 11, the nitrate-nitrite nitrogen value was 0.030 mg/L. The total Kjeldahl nitrogen value in the September bout was 0.53 mg/L. The ratio of total nitrogen (nitrate-nitrite nitrogen + Total Kjeldahl Nitrogen) to phosphorus (approximately 19:1 in August and 14:1 in September) means that the lake is on the borderline between being "nitrogen limited" rather than "phosphorus limited." Water bodies with low nitrogen-phosphorus ratios can sometimes experience blooms of nuisance blue-green algae (these algae can use atmospheric nitrogen as a nutrient source). A blue-green algae bloom was observed during the summer of 2004.

Chlorophyll "a" concentration is a measure of the amount of algae particles in the water column. Chlorophyll "a" was 10.7 ug/L on August 7 and 5.87 ug/L on September 11. The higher August value would cause a characterization of eutrophic for the Gile Flowage. The lower September value indicated a lower algae population at that time (recall also that the water was more transparent during September).

The Carlson Trophic State Indices[4] (TSI) are calculated measures using total phosphorus, chlorophyll "a", and Secchi depth to calculate indicators of trophic status. The calculated values are presented in Table 4. Values from the Gile Flowage range from 48 to 60 (mean value of 55) and this generally places Gile Flowage at the lower boundary of a classical eutrophic lake.

Table 4. Water Chemistry Results for the Gile Flowage.

Analyte	August 7, 2005	September 11, 2005
Alkalinity	14.3 mg/L	13.2 mg/L
Total Phosphorus	0.041 mg/L	0.034 mg/L
Nitrite-Nitrate Nitrogen	Non-Detect	0.030 mg/L
Total Kjeldahl Nitrogen	0.67 mg/L	0.53 mg/L
Total Suspended Solids	2.0 mg/L	Non-Detect
Chlorophyll "a"	10.7 ug/L	5.87 ug/L
Ratio of Total N : Total P	19.0	13.7
Trophic State Index[5] (Phosphorus)	58	55
Trophic State Index (Chlorophyll "a")	54	48
Trophic State Index (Sechhi Depth)	60	54
Low-level Mercury	Not sampled	2.03 ng/L

4 *TSI 30-40: Deeper lakes still exhibit classical oligotrophy, but some shallower lakes will become anoxic in the hypolimnion during the summer. TSI 40-50: Water moderately clear, but increasing probability of anoxia in hypolimnion during summer. TSI 50-60: Lower boundary of classical eutrophy: Decreased transparency, anoxic hypolimnia during the summer, macrophyte problems evident, warm-water fisheries only. TSI 60-70: Dominance of blue-green algae, algal scums probable, extensive macrophyte problems. TSI 70-80: Heavy algal blooms possible throughout the summer, dense macrophyte beds, but extent limited by light penetration. Often would be classified as hypereutrophic. TSI >80: Algal scums, summer fish kills, few macrophytes, dominance of rough fish.*

5 Carlson Trophic State Indices were calculated with formulae published in Carlson and Simpson (1996). *TSI (Secchi) = 60 - 14.41 ln Secchi disk (meters); TSI (Chlorophyll a) = 9.81 ln Chlorophyll a (µg/L) + 30.6; TSI (Phosphorus) = 14.42 ln total phosphorus (ug/L) + 4.15; where TSI = Carlson trophic state index and ln = natural logarithm*

Mercury concentration in Gile Flowage water was found to be 2.03 ng/liter (2.03 parts per trillion). It is also found in the Flowage sediments (see next subsection).

Mercury is found in the environment in several forms. Most of the mercury in water, soil, plants, and animals is inorganic and organic mercury (primarily methyl-mercury). Mercury exists in the environment through both natural and human-caused sources (such as solid waste incineration, fossil fuel combustion, and mining). Mercury is also released to surface waters from naturally occurring mercury in rocks and soils and from industrial activities and wastewater treatment facilities. Mercury also is deposited in surface water from the air through rain and runoff. Mercury can also be mobilized from sediments if disturbed (for example flooding or dredging).

Mercury exists in a number of inorganic and organic forms in water. Methylmercury, the most common organic form of mercury, quickly enters the aquatic food chain and biomagnifies especially in top predators such as fish. Methylmercury is found primarily in the fish muscle (fillets) bound to proteins. Skinning and trimming the fish does not significantly reduce the mercury concentration in the fillet, nor is it removed by cooking processes. Fish at the top of the aquatic food chain, such as walleye, bass, and northern pike, bioaccumulate methylmercury approximately 1 to 10 million times greater than dissolved concentrations found in surrounding waters.[6]

2005 Water Quality Monitoring: Sediment Chemistry

On August 7, we collected sediment samples in three locations on the Gile Flowage (see Figure 1 for Waypoints 299, 300, 302). Results for the sediment metals analyses are presented in Table 5.

6 *This information on mercury was excerpted from http://epa.gov/ost/fishadvice/mercupd.pdf*

Table 5. Sediment Chemistry Results for Gile Flowage.							
Analyte	Gile Flowage Waypoints (WP)			Sediment Quality Guidelines[7]			Units
	WP299	WP300	WP302	TEC	MEC	PEC	
Arsenic	1.6	0.5	1.0	9.8	21.4	33	mg/kg
Barium	95.9	102	75.7	--	--	--	mg/kg
Cadmium	0.86	1.1	0.55	0.99	3.0	5.0	mg/kg
Chromium	23.5	12.7	15.5	43	76.5	110	mg/kg
Copper	23.8	24.0	18.1	32	91	150	mg/kg
Lead	26.8	20.7	22.4	36	83	130	mg/kg
Mercury	0.18	0.230	0.90	0.18	0.64	1.1	mg/kg
Selenium	2.3	3.3	1.3	--	--	--	mg/kg
Silver	Non-Detect	Non-Detect	Non-Detect	1.6	1.9	2.2	mg/kg
Zinc	100	79.0	68.8	120	290	460	mg/kg

Metals in the Gile Flowage sediment are general below the *threshold effect concentrations* ("TEC" in Table 5) published in the Wisconsin Sediment Quality Guidelines. Cadmium concentration in sediment is slightly above the TEC at WP300. Mercury concentration in sediment is at or above the TEC at all three sampling stations (WP299, WP300, and WP302). At WP302 mercury concentration is above the *midpoint effect concentration* (MEC).

7 *The criteria contained in these columns are from the Wisconsin Consensus-Based Sediment Quality Guidelines - Recommendations for Use & Application. Interim Guidance Developed by the Contaminated Sediment Standing Team December 2003. WT-732 2003. The guidance will be updated as needed. Available at: http://dnr.wi.gov/org/aw/rr/technical/cbsqg_interim_final.pdf . The values are based on the concentrations of various metals at which toxic effects to benthic-dwelling organisms might occur. "TEC" (Threshold Effect Concentration) is the concentration below which toxicity to benthic organisms is unlikely. "PEC" (Probable Effect Concentration) is the concentration at which toxic effects on benthic organisms is likely. "MEC" (Midpoint Effect Concentration lies between the TEC and PEC).*

RECOMMENDATIONS FOR COMPREHENSIVE LAND USE PLANNING

When it comes to comprehensive land use planning for the Gile Flowage and its surrounding lands and communities, it is crucial to identify those features of the ecosystem and landscape that are of exceptional quality and importance. These are the assets and opportunities that are presented to the planners. In many cases these will be elements of the "desired future condition" toward which planners and the community will aspire. Natural features, wildlife, and high environmental quality are often traits identified by the public as needing protection or restoration treatment in comprehensive plans. It is also important for Gile Flowage area land-use planners to consider the potential environmental threats to the ecosystems that will be influenced by their planning. In this section of the report, we outline important ecosystem features and threats with special reference to comprehensive land planning.

Important Ecosystem Features of Gile Flowage (Assets and Opportunities)

The Gile Flowage is comprised of some outstanding ecosystem features that deserve consideration in future land use planning and management. These are listed and briefly described in this subsection.

Good water quality – Gile Flowage is a productive aquatic ecosystem with neutral pH and sufficient alkalinity to protect against acid precipitation. It seems to be transitional between being a nitrogen-limited and a phosphorus-limited system.

High quality riparian area around Flowage – Gile Flowage has a high quality riparian forest that surrounds the Flowage. This riparian area exhibits relatively little forest-fragmentation and serves many functions to the environment ranging from terrestrial habitat for plants and animals to protection from run-off (by way of filtering) to contributing large woody material habitat to the Flowage.

Diverse fish community – Gile Flowage contains a diverse community of fishes that supports a good recreational resource for fishermen. The fish community is composed of warm-water species whose populations are supported by natural reproduction as well as periodic WDNR stocking.

Reasonable level of human recreation – Because of it large size and small human population, recreational pressures on the Gile Flowage are currently at a reasonable level, a condition that contributes to a high quality recreational experience by fishermen, boaters, canoeists, and kayakers.

Islands on the Flowage – Islands on the Gile Flowage add greatly to the diversity and aesthetic appeal of the Flowage. They break up the viewscape giving a recreational user the impression of having few people on the Flowage. The islands also effectively increase the amount of littoral zone in the Flowage and thereby increase aquatic organism habitat and productivity.

Bald eagle and common loon nesting and use – Bald eagles and common loons are top predators in the aquatic ecosystems of northern Wisconsin. Their presence as breeding pairs on the Gile Flowage is a great indicator of environmental quality. Beyond being "canaries in the coal mine," the value of their presence cannot be over-estimated – they are symbols of the north that attract people to a special environment.

Engaged and interested residents and Flowage users – Human stakeholders in the Gile Flowage landscape should also be considered as an important resource and asset to land-use planners. These people are potential monitors and watchdogs of the ecosystem. They should be engaged in the planning and management process.

Ecosystem restoration experts are quick to point out that it is hugely more economical to protect and maintain healthy ecosystems then to try to restore those that are degraded. Gile Flowage planners are fortunate to be provided with a basically healthy ecosystem rather than an impacted system that needs expensive and labor-intensive treatment.

Possible Threats to the Gile Flowage Ecosystem

It is also essential for Gile Flowage land-use planners to be aware of potential threats to the Flowage and surrounding areas. Land-use planning can often serve to curtail these threats in a direct and effective way. Below we list and briefly describe potential threats.

Least restrictive lake classification status – The Gile Flowage is classified as a *Class 1 lake* in Iron County's 2-tiered Lake Classification System. This is the least restrictive category using the minimum state shoreline setbacks and lot size restrictions. This classification leaves the Gile Flowage riparian area vulnerable to fragmentation and degradation from development and land use.

Increasing development – Shoreland development pressures are burgeoning in northern Wisconsin. Minimally developed shorelands such as Gile Flowage are especially attractive as places to be exploited. The uncertainty of long-term ownership by power company interests magnifies the potential for future development of the Flowage.

Increasing recreational use – Large reservoirs have become popular destinations for high-tech fishermen with large boats and motors and "tournament-fishing" mentality. Although the current levels of recreation on the Gile Flowage seem reasonable, more and more people are discovering this little-known area. Simply typing in "Gile Flowage" on an internet search engine gives an indication of the potential increase in use as numerous "hits" on fishing-oriented sites and chat groups tout the potential fishing opportunities on the Gile Flowage.

Uncertainties over future reservoir management by Xcel – The old adage that "nothing lasts forever" seems to be contradicted by the historically long-term ownerships of riparian lands by power company interests in Wisconsin and Michigan. In the current economic environment, however, nothing is certain. Stockholder demands can drive change quickly affecting the way the Gile Flowage is managed by it current principal owner (Xcel) or even whether the reservoir remains under current ownership. Changes in status quo of management and/or ownership could have significant consequences on the Flowage.

Sale of public property on reservoir – Long-term public ownership of property on Gile Flowage cannot be considered immutable. More and more cash-strapped municipalities find it difficult to resist the temptation (or fiscal necessity) of selling valuable public lands for short - term budgetary benefit.

Water level fluctuation – The large seasonal excursions of water level in the Gile Flowage has had, and continues to have, a large effect on the biota of the Flowage. Aquatic habitat is diminished by this major and frequent disturbance. Although the Flowage has likely reached some kind of ecological equilibrium, fish habitat in the form of large woody debris and aquatic plant beds is not what it could be. Fish population dynamics are almost certainly affected.

FERC jurisdiction uncertainties – The Federal Energy Regulatory Commission (FERC) is responsible for licensing of hydroelectric facilities and other types of dams throughout the United States. FERC typically requires environmental monitoring that provides periodic and ongoing data. In spite of the fact that the Gile Flowage is maintained for the purposes of regulating water flow to two downstream hydroelectric facilities, FERC has not claimed jurisdiction over the Gile Flowage dam and impoundment. This leaves uncertainties in authority and environmental requirements in the event that decommissioning of the Gile Flowage Dam was proposed.

Exotic / aggressive species – Two non-native invaders have already colonized the Gile Flowage (spiny water flea and Chinese mystery snail) and these pose unknown threats to the Gile Flowage ecosystem and other nearby ecosystems (because of their possible, even likely, colonization to other waters from the Gile Flowage). Other alien species (such as purple loosestrife and Eurasian milfoil are also likely invaders and should be carefully monitored.

Bluegreen algae blooms – Periodic bluegreen algae blooms occur in the Gile Flowage. This is often an indicator of excessive nutrients. Since aquatic macrophytes are not greatly abundant they are not competing for the available nutrients possibly allowing periodic blooms. Bluegreen algae blooms tend to be a nuisance in that they can foul recreational gear and cause aesthetic problems from bad odor. Some species of bluegreen algae pose potential health threats to wildlife, domestic animals, and humans.

Low diversity and sparse distribution of aquatic plants – The low diversity and sparse distribution of aquatic vegetation has impacts on fish and wildlife habitat of Gile Flowage. Some of this is due to the inherent low light transparency of the water and bedrock substrate and some is due to the great fluctuations in water level. The lack of plants in the littoral zone is of particular concern when it comes to good fish and fish food habitat.

Mercury in the system – Mercury is present in major components of the Gile Flowage ecosystem: water, sediments, and animals. One principal concern is that mercury is found in Gile Flowage fish tissue at high enough levels to warrant the WDNR issuing a *fish consumption advisory* for the Flowage. Humans can follow consumption guidelines, but bald eagles and common loons cannot and as top level predators they are the most vulnerable to mercury toxicity. The ultimate source(s) of mercury to the Flowage is (are) unknown, but its presence in the sediment and surface water provides a potential ongoing source of mercury to the food chain.

Non-point source pollution – NPS pollution is an ongoing concern for the Gile Flowage and its watershed. Because streams enter the Flowage the possibility of a toxic spill or sediments from poor stream crossing, poor forestry practices, or other disturbance can come to the Flowage from many points upstream. Land-use planning should consider precautions that minimize NPS inputs to the Flowage ecosystem.

To be able to fully integrate aquatic ecosystem management into the comprehensive land use planning is a great opportunity. The land influences the water and the water influences the land. The ecosystems are functionally connected. Yet, all too often aquatic and terrestrial ecosystems are treated as completely separate entities when it comes to planning. Little concern is directed toward how a particular land use might impact the water features of the landscape. Even if a comprehensive land use plan does not involve itself directly with surface water management, it should at least establish a foundation for this activity and certainly should attempt to avoid land-based actions that would be detrimental to aquatic resources.

Appendix A
Figures

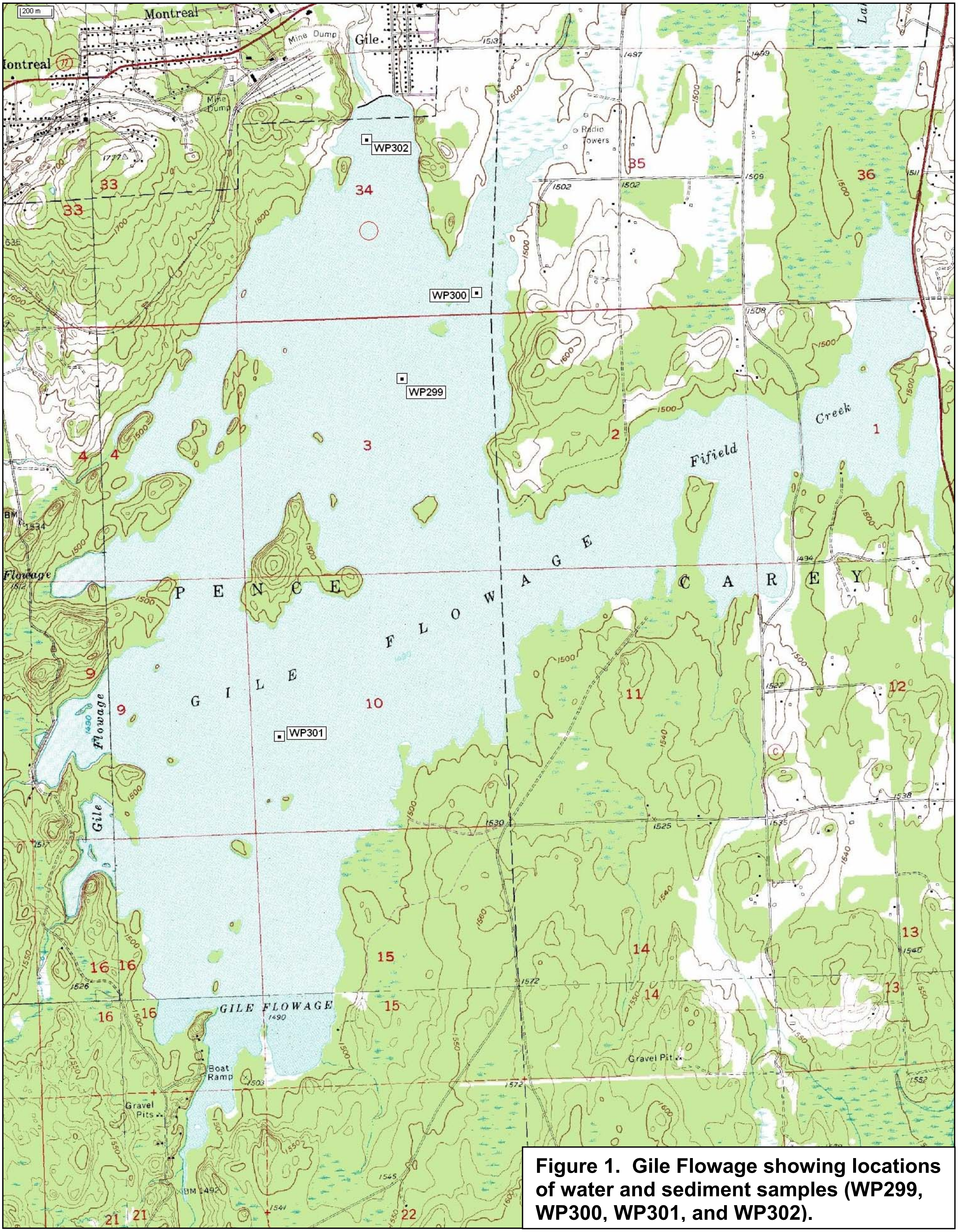

Figure 1. Gile Flowage showing locations of water and sediment samples (WP299, WP300, WP301, and WP302).

Figure 2. Undated depth and habitat map of Gile Flowage (source: Appendix I in 1996 WDNR Lake Survey Summary).